CLAIMS

1. (Amended) A control system for an internal combustion engine provided with:

a fuel injector for injecting fuel into an engine combustion chamber,

an EGR system for recirculating part of the engine exhaust into the engine combustion chamber as EGR gas, and

a cylinder pressure sensor for detecting a pressure inside the engine combustion chamber,

said control system for an internal combustion engine provided with:

combustion parameter calculating means for calculating a combustion parameter expressing an engine combustion state including at least one of a cylinder heat release amount, a combustion start timing, and a combustion period based on a relationship predetermined using the combustion chamber pressure detected by said cylinder pressure sensor and an engine crank angle and

correcting means for correcting at least one of a fuel injection amount, fuel injection timing, and amount of EGR gas so that the calculated combustion parameter becomes a target value predetermined in accordance with the engine operating conditions and

selecting as said combustion parameter a combustion parameter giving the smallest error in accordance with the fuel injection mode or combustion mode of the engine among a plurality of types of combustion parameters expressing said engine combustion state calculated based on the combustion chamber pressure and engine crank angle and using said selected combustion parameter for the correction by said correcting means.

2. A control system of an internal combustion engine as set forth in claim 1, wherein said fuel injection mode includes a fuel injection mode comprising a main fuel injection and a multi-fuel injection injecting fuel into the engine combustion chamber before

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or after or both before and after the main fuel injection combined

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in accordance with need.

3. A control system of an internal combustion engine as set forth in claim 2, wherein said injection correcting means first corrects an overall fuel injection amount to the combustion chamber and main fuel injection timing and then, when performing multi-fuel injection, corrects the fuel injection amount or fuel injection timing of said multi-fuel injection in the state where the main fuel injection has been corrected.

4. A control system of an internal combustion engine as set forth in claim 2, further provided with sensor calibrating means for correcting error of said cylinder pressure sensor output based on actual combustion chamber pressure detected by said cylinder pressure sensor at a predetermined crank angle.

5. A control system of an internal combustion engine as set forth in any one of claims 2 to 4, wherein said engine operating conditions is defined by an engine speed and accelerator opening degree.

6. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameters are a maximum value of combustion chamber pressure after the start of combustion and a crank angle where the combustion chamber pressure becomes the maximum.

7. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameter is a crank angle where a rate of change of combustion chamber pressure becomes maximal.

8. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameter is a crank angle where a second derivative of combustion chamber pressure becomes maximal.

9. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameters are a maximum value of a product of

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the combustion chamber pressure and combustion chamber actual volume and a crank angle where the product of the combustion chamber pressure and combustion chamber actual volume becomes maximum.

10. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameter is a difference ΔPVmax between a maximum value of a product of the combustion chamber pressure and combustion chamber actual volume and a product of the combustion chamber pressure due to only compression in the case of assuming no combustion occurred and combustion chamber actual volume at a crank angle where the product of the combustion chamber pressure and combustion chamber actual volume becomes maximum.

11. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameter is a crank angle where a cylinder heat release rate becomes maximum.

12. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameter is an overall amount of cylinder heat release.

13. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameter is a difference between a maximum value of cylinder pressure after the start of combustion and a cylinder minimum pressure in the interval after compression top dead center to when combustion is started in the combustion chamber.

14. A control system of an internal combustion engine as set forth in claim 5, wherein said selected combustion parameter is a difference between a maximum value of cylinder pressure after the start of combustion and a combustion chamber pressure due only to compression in the case assuming no combustion occurred at the crank angle where said cylinder pressure becomes maximum.

15. A control system of an internal combustion engine as set forth in claim 5, wherein said multi-fuel injection includes pilot fuel injection performed before main fuel injection, and said correcting means uses as a combustion parameter the difference between a product of a combustion chamber pressure and combustion chamber actual volume when fuel injected by main fuel injection is ignited and a product of a combustion chamber pressure due to only compression in the case assuming no combustion occurred and the combustion chamber actual volume at a crank angle where fuel injected by the main fuel injection is ignited so as to correct a pilot fuel injection instruction.

16. A control system of an internal combustion engine as set forth in claim 5, wherein said multi-fuel injection includes after injection performed after main fuel injection, and said correcting means uses as a combustion parameter the difference ($\Delta PVmax-\Delta PVafter$) between a difference $\Delta PVmax$ between a maximum value of a product of a combustion chamber pressure and combustion chamber actual volume and a product of a combustion chamber pressure when fuel injected by after injection is ignited and a combustion chamber actual volume and a difference $\Delta PVafter$ between a product of a combustion chamber pressure when fuel injected by after injection is ignited and the combustion chamber actual volume and the product of a combustion chamber pressure due to only compression in the case assuming no combustion occurred and the combustion chamber actual volume at a crank angle where fuel injected by the after injection is ignited so as to correct an after injection instruction.

17. A control system of an internal combustion engine as set forth in claim 6, wherein said correcting means performs said correction using as said combustion parameters a maximum value of a combustion chamber pressure after the start of combustion and a crank angle

where the combustion chamber pressure becomes maximum only for the main fuel injection.

18. A control system of an internal combustion engine as set forth in claim 5, wherein said system is further provided with a throttle valve for throttling the engine intake air amount and wherein said injection correcting means corrects the main fuel injection, then uses as combustion parameters the difference between the combustion chamber pressure due to compression at compression top dead center and the cylinder minimum pressure in the interval from compression top dead center to when combustion is started in the combustion chamber and the combustion chamber pressure maximum value after the start of combustion so as to correct said throttle valve opening degree and main fuel injection timing so that the values of these two combustion parameters match their target values.

19. A control system of an internal combustion engine as set forth in claim 18, wherein said engine can operate switching between a normal combustion mode of injecting fuel after the compression stroke and performing combustion by a large rate of excess air and a low temperature combustion mode of advancing the fuel injection timing from the normal combustion mode and increasing the amount of EGR gas and wherein said injection correcting means corrects said throttle valve opening degree and main fuel injection timing so that the values of said two combustion parameters match their target values when switching modes between said normal combustion mode and low temperature combustion mode.

20. A control system of an internal combustion engine as set forth in claim 1, wherein said combustion mode of said engine includes modes of different amounts of supply of EGR gas to the combustion chamber.

21. A control system of an internal combustion engine as set forth in claim 20, wherein said selected combustion parameter is a time Δt, calculated based on a

value of a product PV of a combustion chamber pressure P detected by a cylinder pressure sensor and a combustion chamber volume V determined from the crank angle θ, from the start of fuel injection from the fuel injector to when the value of said PV becomes the maximum value PVmax and wherein said correcting means adjusts the amount of said EGR gas so that said time Δt becomes a predetermined target value.

22. A control system of an internal combustion engine as set forth in claim 21, wherein further said combustion parameter calculating means further calculates a product PVbase between a combustion chamber pressure occurring due to only compression of the piston in the case of assuming that combustion did not occur in the combustion chamber and a combustion chamber volume determined from the crank angle and uses a value of PVbase at the crank angle θpvmax where said PV becomes the maximum value PVmax to calculate a difference ΔPVmax between PVmax and PVbase and wherein said correcting means further controls the fuel injection amount and fuel injection timing from said fuel injector so that the values of ΔPVmax and said θpvmax become their predetermined target values.

23. A control system of an internal combustion engine as set forth in claim 21 or 22, wherein said target value is determined in accordance with an engine speed and accelerator opening degree.

24. A control system of an internal combustion engine as set forth in claim 23, wherein said internal combustion engine is a compression ignition engine.

25. A control system of an internal combustion engine as set forth in claim 24, wherein said engine can operate switching between two modes of a normal combustion mode of injecting fuel after the compression stroke and performing combustion by a large rate of excess air and a low temperature combustion mode of

advancing the fuel injection timing from the normal combustion mode and increasing the amount of EGR gas and controls the amount of EGR gas based on the value of said Δt when operating in said low temperature mode of the engine.

26. A control system of an internal combustion engine as set forth in claim 25, wherein said correcting means further makes the fuel injection timing continuously change from the injection timing at the normal combustion mode to the target fuel injection timing at the low temperature combustion mode over a predetermined transition time when switching from said normal combustion mode to low temperature combustion mode and controls the amount of EGR gas based on the value of the Δt calculated using the target fuel injection timing at the low temperature combustion mode after switching instead of the actual fuel injection timing during said transition time.

27. A control system of an internal combustion engine as set forth in claim 20, wherein said selected combustion parameter is a time Δtd, determined based on a value of PV^{κ} calculated from a combustion chamber pressure P detected by said cylinder pressure sensor, a combustion chamber volume V determined from a crank angle θ, and a specific heat ratio κ of the combustion gas, from the start of fuel injection from a fuel injector to when the value of said PV^{κ} becomes the minimum value $PV^{\kappa}min$ and wherein said correcting means controls the amount of EGR gas so that said Δtd becomes a predetermined target value.

28. A control system of an internal combustion engine as set forth in claim 20, wherein said selected combustion parameter is a time Δtc, determined based on a value of PV^{κ} calculated from a combustion chamber pressure P detected by said cylinder pressure sensor, a combustion

chamber volume V determined from a crank angle θ, and a specific heat ratio κ of the combustion gas, from when the value of said PV^{κ} becomes the minimum value $PV^{\kappa}min$ after the start of fuel injection from a fuel injector to when it becomes the maximum value $PV^{\kappa}max$ and wherein said correcting means adjusts the amount of EGR gas so that said Δtc becomes a predetermined target value.

29. A control system of an internal combustion engine as set forth in claim 27 or claim 28, wherein said fuel injector performs pilot injection for injecting a small amount of fuel into the combustion chamber before main fuel injection and wherein said combustion parameter calculating means starts detecting the value of said $PV^{\kappa}min$ after the start of main fuel injection.

30. A control system of an internal combustion engine as set forth in claim 1, wherein said selected combustion parameter is a rate of change $d(PV^{\gamma})/d\theta$ of the parameter PV^{γ} with respect to the crank angle θ calculated as a product of a γ power of V and P using a combustion chamber pressure P detected by said cylinder pressure sensor, a combustion chamber volume V determined from the crank angle θ, and a predetermined constant γ and wherein said correcting means detects a combustion period including a combustion start timing and end timing in the combustion chamber based on said rate of change and corrects at least one of the fuel injection timing and fuel injection pressure from said fuel injector so that said combustion period matches a predetermined duration.

31. A control system of an internal combustion engine as set forth in claim 30, wherein further said correcting means calculates an amount of cylinder heat release in said combustion period based on the value of a parameter PV calculated as a product of said combustion chamber pressure P and said combustion chamber volume V at said combustion start timing and said combustion end

timing and corrects the fuel injection amount from said fuel injector so that the calculated amount of cylinder heat release becomes a predetermined value.

32. A control system of an internal combustion engine as set forth in claim 31, wherein said engine performs, in addition to main fuel injection, multi-fuel injection for injecting fuel into the engine combustion chamber before or after or both before and after the main fuel injection and wherein said correcting means corrects the fuel injection timing or fuel injection pressure based on the value of said $d(PV^{\gamma})/d\theta$ for at least one fuel injection in the multi-fuel injection and corrects the fuel injection amount based on the value of said PV.